# PHYSICS

## BOOKS - BHARATI BHAWAN PHYSICS (HINGLISH)

## EXPANSION OF SOLIDS

Others

**1.** A certain property $\eta$ varies according to the law $\eta = \frac{\alpha(t - t_0)}{1 + \alpha t}$ where $\alpha$ is a constant and $t_0$ is a temperature less than $t$. If $\eta > 1$ is unthinkable what is the absolute zero on this property? What is the relation of $t$ and $T$ on this property?

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**2.** A circular hole in an aluminium plate is $2.50cm$ at $0^\circ C$. What is its diameter when it temperature is raised to $100^\circ C$?

(The linear expansivity of aluminium $= 23 \times 10^{-6} K^{-1}$)

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**3.** A steel metere scale isto be ruled so that the millimetre intervals are accurate within about $5 \times 10^{-5} mm$ at a certain temperature. What is the maximum temperature variation allowable during the ruling? ($\alpha$ for steel $= 11 \times 10^{-6}.^\circ C^{-1}$)

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**4.** A weight thermometer contains $500g$ of mercury at $0^\circ C$. If the temperatue is raised to $100^\circ C$ how much mercury will be expelled. (Cubical expansivity of mercur $= 182 \times 10^{-6}.^\circ C^{-1}$ and that of glass $= 27 \times 10^{-6}.^\circ C^{-1}$)

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**5.** The density of air at NTP is $1.293 kgm^{-3}$. Calculate its density when its temperature is $16.6^{\circ} C$ and pressure is $75 cm$ of mercury.

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**6.** A piece of metal weighs 46 g in air and 30 g in lipuid of density $1.24 \times 10^3 kgm^{-3}$ kept at $27^0 C$. When the temperature of the liquid is raised to $42^0 C$ the metal piece weights 30.5 g . The density of the liqued at $42^0 C$ is $1.20 \times 10^3 kgm^{-3}$. Calculate the coefficient of linear expandsion of the metal.

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**7.** A vessel of volume $V = 0.03 m^3$ contains an ideal gas at $0^{\circ} C$. After a portion is let out, the presure in the vessel decreases by $\Delta p = 0.78 atm$

(the temperature remaining constant). Find the mass of the released gas. The density under normal conditions is $\rho_0 = 1.3 kgm^{-3}$

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**8.** A vessel of volume $V$ contains $n_1$ moles of oxygen and $n_2$ moles of carbon dioxide at temperature $T$. Assuming the gases to be ideal, find,

(a) the pressure of the mixture,

(b) the mean molar mass of the mixture.

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**9.** The distance between the towers at the ends of the main span of a bridge is $2400m$.The sag of the cable half -way between the towers at $30^\circ C$ is $500m$. If $\overline{\alpha} = 12 \times 10^{-6} K^{-1}$ for the cable, calculate the change in length of the cable betwen the towers and the change in sag midway between the towers for a change in temperature from $10^\circ C$ to $42^\circ C$

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**10.** A steel rod is $3.000cm$ in diameter at $25^\circ C$. A brass ring has an interior diameter of $2.9912cm$ at $25^\circ C$. At what common temperature will the ring just slide onto the rod? $\alpha_{\text{brass}} = 18 \times 10^{-6} K^{-1}$ and $\alpha_{\text{steel}} = 12 \times 10^{-6} K^{-1}$

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**11.** Two mettalic strips each of length $l_0$ and thickness $d$, temperature $T_0$ are riveted together so that their ends coincide. One strip is maxe of a metal of coeficient of expansioin $\alpha_1$ and the other of a metal with a coefficient $\alpha_2$, where $\alpha_2 > \alpha_1$. When this bimetallic strip is heated to a temperature $T_0 + \Delta T$, find the radius of curvature $R$ of the strip.

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**12.** A circular hole in an aluminium plate has a diameter of $4cm$ at $0^\circ C$. What is its diameter when the temperature of the plate is raised to

$100^\circ C$? (Linear expansivity of aluminium $= 23 \times 10^{-6} K^{-1}$)

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**13.** An iron scale is correct at $0^\circ C$ an at this temperature, a zinc rod measures $1m$ on this scale. What will be the length of the zinc rod as measured by the iron scale when both the are at $100^\circ C$? (Linear expansivity of zinc $= 126 \times 10^{-6} K^{-1}$ and linear expansivity of iron $= 12x10^{-6} K^{-1}$)

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**14.** If a clock with an uncompensated pendulum of steel keeps correct time at $15^\circ C$ how many seconds would it lose is 24 hours at a temperature of $25^\circ$? (Linear expansivity of steel $= 12 \times 10^{-6} K^{-1}$)

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**15.** The linear expansivity of glass is $8 \times 10^{-6} K^{-1}$ and cubical expansivity of mercury is $18 \times 10^{-5} K$. What volume of mercury must be placed inside a flask of 300cc, so that the volume of the flask not occupied by mercury may remain the same all temperature?

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**16.** A porcelain crucible is filled with $1kg$ of mercury at room temperature $(20^{\circ} C)$. The crucible is then placed inside a furnance, kept there for sufficient time and finally removed. It is found that it contains only $0.8Kg$ of mercury. Calculate the temperature of the furnace. (Average cubical expansivity of mercury $= 18.2 \times 10^{-5} K^{-1}$ and that of porcelain $= 2 \times 10^{-5} K^{-1}$)

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**17.** The scale of a barometer is made of brass and is correct is $15^{\circ} C$. The reading of the barometer is $0.754m$ at $5^{\circ} C$. Correct this reading to $0^{\circ} C$.

(Linear expansivity of brass $= 18x10^{-6}K^{-1}$ and cubical expansivity of mercury $= 18 \times 10^{-5}K^{-1}$)

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**18.** A sinker of weight $w_0$ ha an apparent weight $w_1$ when weighed in a liquid at temperature $t_1$ and $w_2$ when weighed in the same liquid at temperature $t_2$. The coefficient of cubical expansion of the material of the sinker is $\beta$. What is the coefficient of volume expansion of the liquid?

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**19.** A vessel of volume $0.02m^3$ contains a mixture of hydrogen and helium, at $20^\circ C$ and 2 atm pressure. The mass of the mixture is equal to $5g$. Find the ratio of the mass of hydrogen to that of helium in the given mixture.

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**20.** A vessel contains $7g$ of nitrogen and $11g$ of carbon dioxide at a temperature of $T = 290K$ and pressure of 1 atm. Find the density of this mixture, assuming the gases to be ideal.

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**21.** A glass tube is attached to the bottom of a thin iron rod of length $1m$. To what height must the glass tube be filled with mercury so that the centre of mass of the pendulum formed will not rise or all with changes in temperature?

(Linear expansivity of glass $= 9 \times 10^{-6}K^{-1}$, that of iron $= 12x10^{-6}K^{-1}$ and cubical edxpansivity of mercury $= 18.2 \times 10^{-5}K^{-1}$)

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**22.** A mercury thermometer reads $99.25^{\circ}C$ when immersed in a steam bath in such a way that the entire of its stem above is $0^{\circ}C$ graduation is

outside the bath. The temperature of the room is $20^\circ C$. When the whole of its steam is pushed into the bath, the thermometer reads $100.5^\circ C$. Calculate the coefficient of cubical expansivity of mercury. (Given theat linear expansivity of glass $= 8 \times 10^{-6} K^{-1}$)

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**23.** A glass hydrometer reads 9200 in a liquid at $45^\circ C$. What would be the reading at $15^\circ C$? (Cubical expansivity of the liquid $= 52. \times 10^{-5}/K$ and that of glass $= 2.4 \times 10^{-5}/K$)

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**24.** A vessel of glass of constant volume contains $340g$ of mercury at $0^\circ C$. When a few spherical iron balls are dropped into the vessel, $85g$ of mercury flow out. When the system is heated to $100^\circ C$, $4.8g$ more of mercury flows out. Calculate the coefficeint of linear expansion of iron. $\left(\gamma_{\text{mercury}} = 180 \times 10^{-6} K^{-1}\right.$

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**25.** A vertical cylinder closed at both ends is divided into two parts by a frictionless piston, each part containing one mole of air. At $300K$ the volume of the upper part is 4 times of the lower part. At what temperature will the volume of the upper part be three times that of the lower part?

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**26.** Two identical vessel are connected by a tube with a valve letting the gas pass from one vessel to the other if the pressure difference is $\Delta p \leq 1.1$ atm. Initially there is a vacuum in one in one vessel while the other contained an ideal gas at $27^{\circ}C$ and 1atm pressure. Then both the vessel are heated to $107^{\circ}C$. Up to what value will the pressure in the first vessel (which had vacuum initially) increase?

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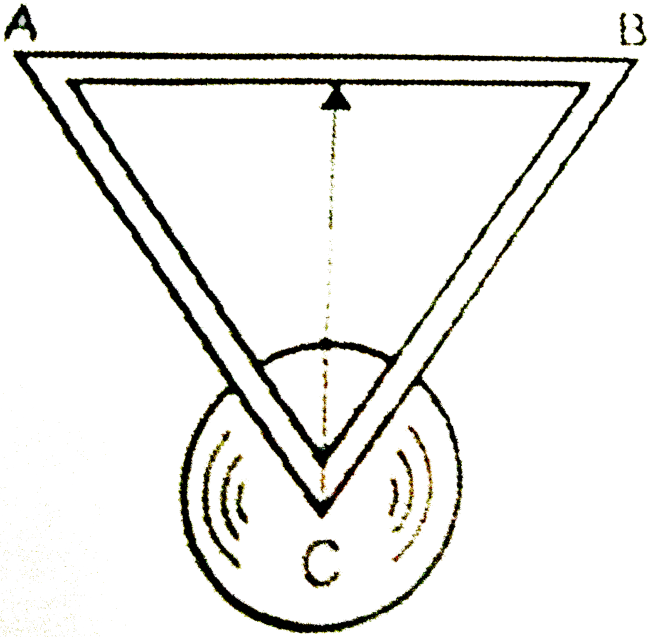
**27.** The compensated pendulum of a clock consista of an isosceles triangular frame of base length $l_1$ and expansivity $\alpha_1$ and side length $l_2$ and expansivity $\alpha_2$. The pendulum is supported as shown in the figure. Calculate the ratio $l_1/l_2$ so that the length of the pendulum may remain unchanged at all temperatures?

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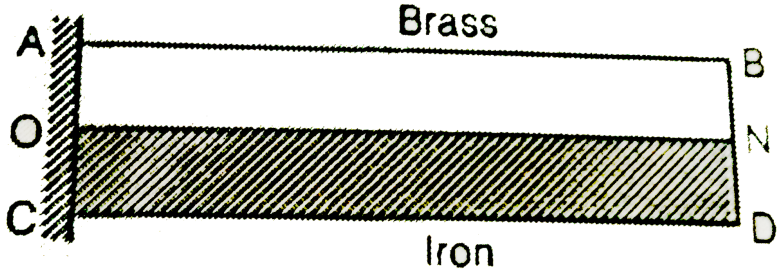
**28.** A bimetallic strip consiting of a brass strip and a steel strip, each of length $1m$ and thickness $1/2$ cm is clamped at one end at $0^\circ C$.Calculate

the depression of the free end when it is heated to $100^{\circ} C$.

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**29.** The pendulum of a clocl beats $1/2$ a second at $20^{\circ} C$. By how many seconds should it be corrected ina month at $30^{\circ} C$? Linear expansivity of the material of the pendulum $= 9 \times 10^{-6} /.^{\circ} C$.

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**30.** Three equal -length straight rods, of aluminium invar and steel all at $20^{\circ} C$, form an equilateral triangle with hinge pins at the vertices. At what temperature will the angle opposite to the invar rod be $59.95^{\circ}$?

$\alpha_{\text{invar}} = 0.7 \times 10^{-6} / C^{\circ}$, $\alpha_{\text{steel}} = 11 \times 10^{-6} / C^{\circ}$, $\alpha_{\text{aluminium}} = 23 \times 10^{-6}$

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**31.** As a result of temperature rise of $32^{\circ}C$ a bar with a crack at its centre buckles upwards. If the fixed distance be $L_0 = 4.0m$ and the temperature coefficient of linear expansion be $\alpha = 25 \times 10^{-6}/C^{\circ}$, find the distance $x$ by which the centre rises.

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**32.** Two rods of different materials but having same length $L$ and cross-sectioinal areas $A$ are arranged end-to-end between fixed supports. The temperature is $T$ and there is no initial stress. The rods are heated so that their temperature increases by $\Delta T$. Find : (a) the displacement of the interface (b) the stress at the interface. The coefficinets of linear expansioin of the materials are $\alpha_1$ and $\alpha_2$ and their Young's modulii are $E_1$ and $E_2$ respectively.

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**33.** A composite bar of length $L = L_1 + L_2$ is made from a bar of material 1 and length $L_1$ attached to a bar of material 2 and length $L_2$. Find the effective linear expansion $\alpha$ of this bar.The coefficinets of linear expansion of the material of the rods are $\alpha_1$ and $\alpha_2$ respectively.

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**34.** The coefficient of linear expansion varies linearly from $\alpha_1$ and $\alpha_2$ in a rod of length $l$. Find the increase in length when its temperature is increased by $\Delta T$.

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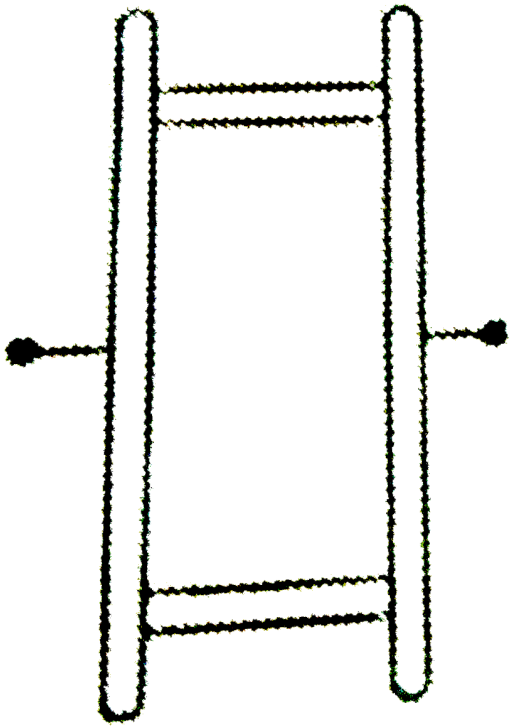
**35.** A capacitor is to be designed to operate, with constant capacitance, in an environment of fluctuating temperature. As shown in the figure the capacitor is a paralel plate capacitor with 'spacer' to change the distance for compensation of temperature effect. If $\alpha_1$ be the coefficient of linear expansion of plates and $\alpha_2$ that of spacer, find the rate of change of

capacitance with temperature and hence find the condition for no change in capacitance with change of temperature. The capacitance of the capacitor is equal to $C$.



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